Varedan Technologies

VSA Series

PWM Servo Amplifiers

VSA-1530-1 Module

VSA-1530-2 Module

VSA-1530-SA Stand Alone

Product User Guide

Revision G

Record of Revisions

Rev	Date	Valid For	Description
A1	1/4/2011	Beta Units	Initial release
B	4/19/11	Production	Added commands and drawings
C	9/14/11	Production	Added Stand Alone information
D	12/20/11	Production	Changed description for analog current monitor
E	9/11/12	Production	Added Find Index commands
F	8/2/13	Production	Added commands
G	12/15/14	Production	Added programming commands, Limits

Technical changes to improve performance may be made at any time without notice!

Contents

1 Introduction

This manual describes the operation and installation of the VSA series PWM servo amplifiers manufactured by Varedan Technologies. This is the section most people skip over, but it does have some useful information, so please take the time to read it.

The VSA Series Pulse Width Modulated (PWM) Servo Amplifiers are designed for high performance OEM applications requiring PWM switching type amplifiers. These fully digital servo amplifiers are available in a variety of power ranges to drive three-phase brushless motors, single-phase brush-type motors or voice coils. These amplifiers operate in position, velocity, or torque (current) mode using either an analog input or digital command, or 2-phase sine input mode using analog inputs.

Programmable commutation options include sinusoidal from a motor mounted encoder, externally commutated 2-phase sine input or trapezoidal commutation using motor mounted hall sensors.

Packaging options include a DC powered module or an AC line powered stand-alone.

Most connections are identical between the module and the stand alone with the exception of the motor connector and the power connector. Please refer to section 6.

The design of these amplifiers includes an on-board high-speed Digital Signal Processor (DSP) which performs the PID loop controls as well as monitors all key system functions in real-time to protect the amplifier in the event of a system fault.

Serial communication options include both USB and RS-232 interfaces. An intelligent operating system allows setup and storage of all system parameters using simple ASCII command over the serial interface. The serial interface can also be used to view all operating parameters in real-time. Non-volatile memory provides storage of the parameters during power off conditions.

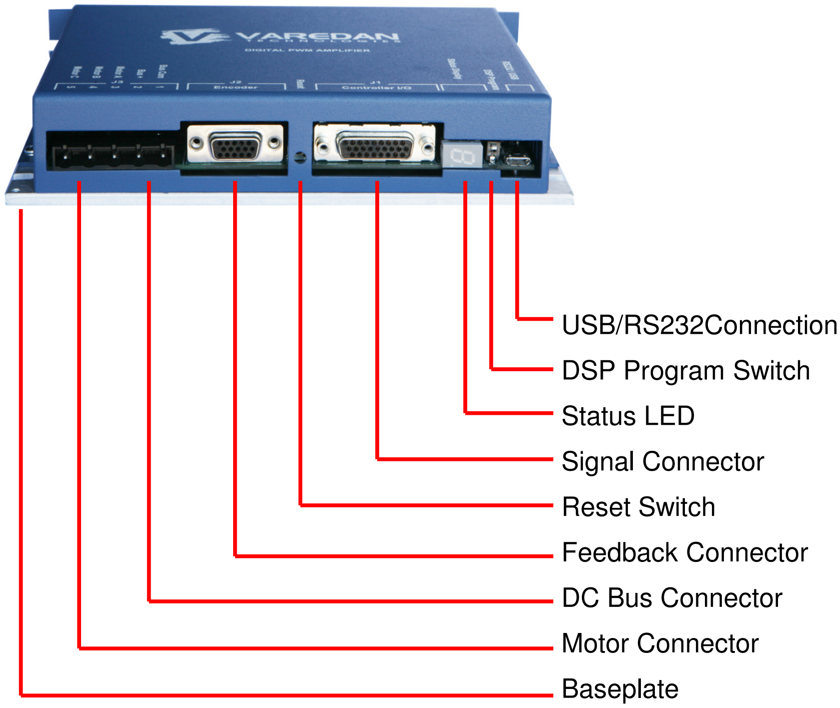
A front-panel 7-segment LED display provides real-time indication of system status. Depending on the mode of operation, up to 20 errors conditions are monitored by the DSP in real-time. The DSP disables the outputs and displays an error code in the event of system malfunction.

The amplifier has a built in operating system that has many commands to perform the set up and configuration of the unit. While it may seem daunting at first to have to learn all of these commands, only a handful are typically used by any particular application. The large number of commands allows this amplifier to be extremely flexible so it can easily be used across many different applications. Please feel free to contact the factory for help with configuration and proper use of the commands.

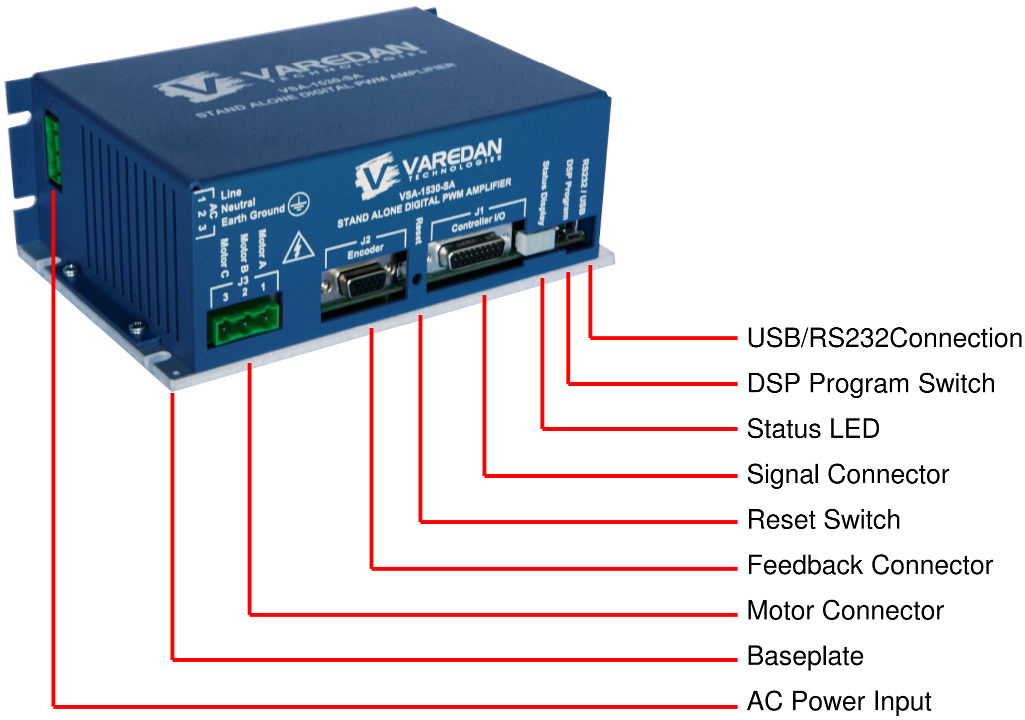
For most applications, once the configuration is set using the serial commands, a simple WRITE command is issued to save the settings in internal non-volatile memory (NVM). Following the WRITE operation, all settings will be restored following a power-on reset so in most cases, no serial communication is required one the unit has been set up and the settings saved. To automate the process of setting up multiple units with the same configuration, a text file can be downloaded to each unit over the serial interface.

1.1 Main Parts

1.1.1 Module Parts



1.1.2 Stand Alone Parts



2 Model Part Numbering

The following table illustrates the various part numbers used to define the available model configurations.

2.1 Modules

VSA - 1530 - 170 - 1 - 1

Varedan switching amplifier
Continuous Power
Peak Power
Maximum DC Bus Voltage
Hardware Configuration Code
   1=Standard Module (as shown top left)
   2=Alternate Connector Configuration (as shown top right)
   3-999=Other customer specified configurations
Software Configuration Code
   1=Standard configuration
   2-999 = Customer specific options

2.2 Stand Alone

VSA - 1530 - SA -170 - 1 - 1

Varedan switching amplifier
Continuous Power
Peak Power
Stand Alone Package
Maximum DC Bus Voltage
Hardware Configuration Code
   1=Standard Module (as shown above)
   2-999=Other customer specified configurations
Software Configuration Code
   1=Standard configuration
   2-999 = Customer specific options

3 Safety Information

You REALLY need to read this information before operating this amplifier.

3.1 Hazardous Voltage Information

△ **CAUTION** △

Hazardous voltages are present at the motor output terminals, input power connection, and within the sheet metal enclosure. Disconnect the power before plugging / unplugging any connections or before servicing or disassembling the enclosure.

3.2 Airflow and Cooling

△ **CAUTION** △

The user must insure proper airflow for the application. Failure to do so may cause permanent damage to the unit and is not covered under warranty.

3.3 Selecting a mounting area

The VSA amplifier module should be mounted in a solid, clean, dry location with adequate ventilation.
Avoid mounting areas that:
Obstruct the intake or exhaust vents.
Allow dust, debris to enter and contaminate the cooling capability of the drive.
Have humidity above 80% or are susceptible to moisture or coolant.

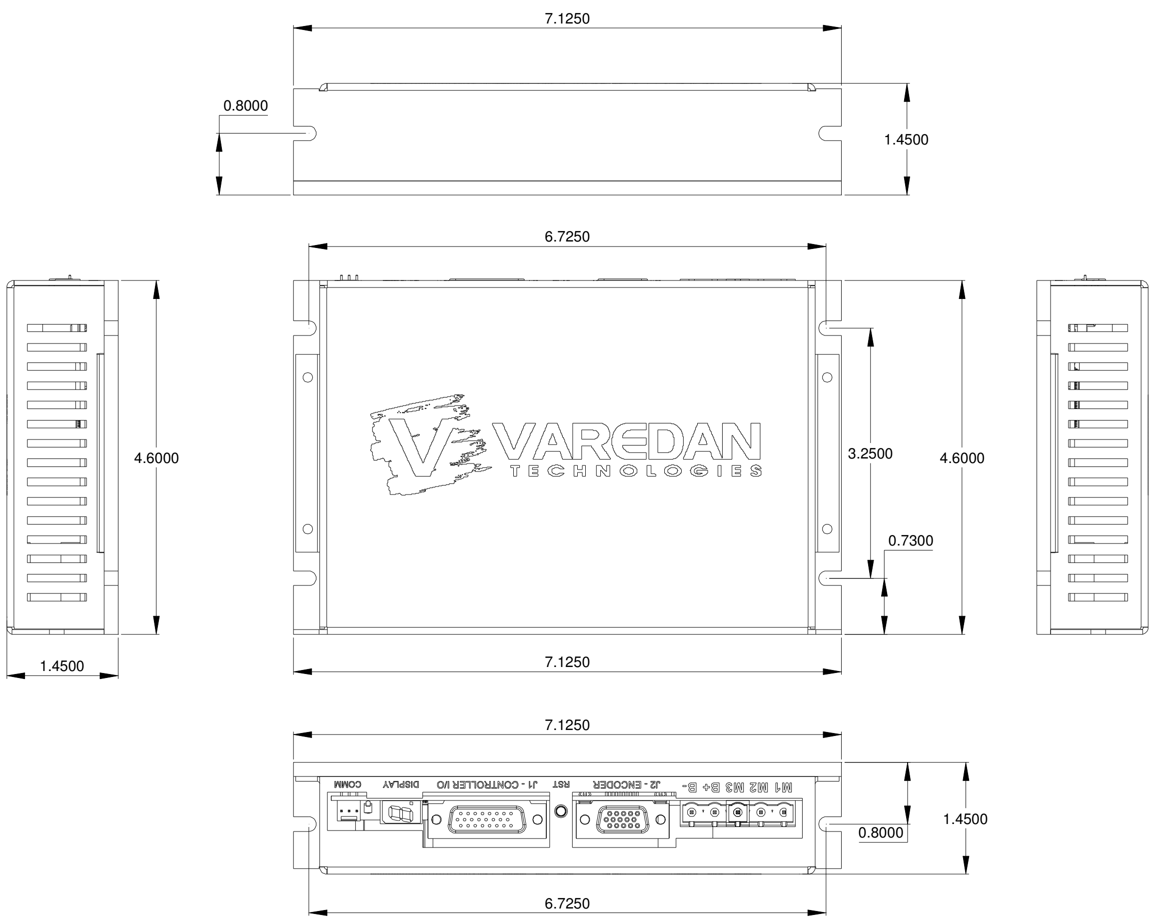
- Are prone to corrosive or flammable materials.
- Have an ambient temperature higher than 85°F (30°C).
- Are under water.
- Vibrate, are susceptible to vibration or that could transmit the cooling fan vibration to sensitive test equipment.

4 Module Specifications

4.1 Mechanical & Environmental

Size	7.125 X 4.60 X 1.45 inches
Weight	0.94 lb (0.43 kg)
Ambient temperature	0 to +45 ℃ operating, -40 to +85 ℃ storage
Humidity	0% to 95%, non-condensing
Contaminants	Pollution degree 2
Environment	IEC68-2: 1990
Cooling	Heat sink and/or forced air-cooling may be required for continuous power output

Figure 1: VSA Module Dimensions

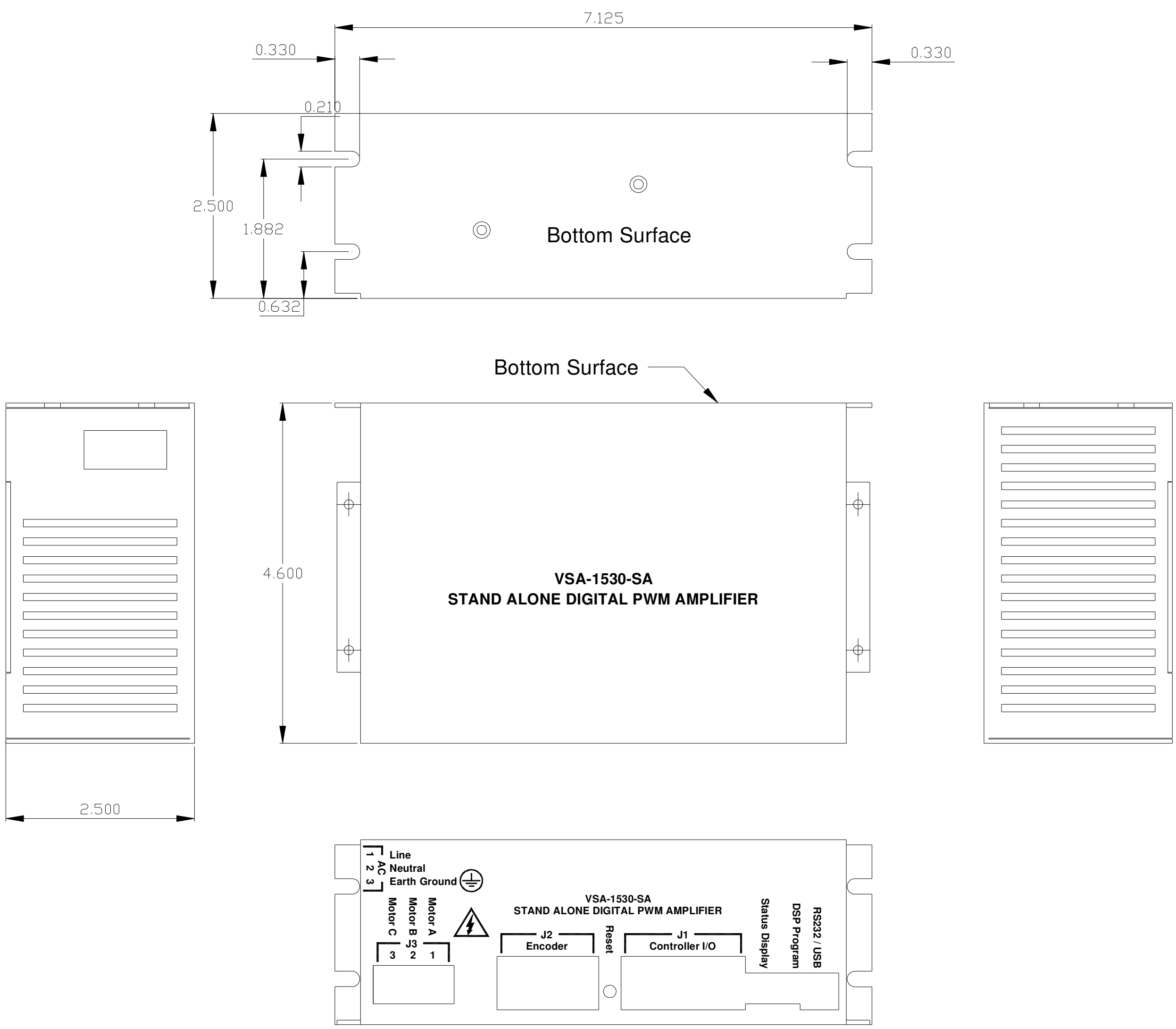


5 Stand Alone Specifications

5.1 Mechanical & Environmental

Size	7.125 in X 4.60 in X 2.50 inches
Weight	0.94 lb (0.43 kg)
Ambient temperature	0 to +45 °C operating, -40 to +85 °C storage
Humidity	0% to 95%, non-condensing
Contaminants	Pollution degree 2
Environment	IEC68-2: 1990
Cooling	Heat sink and/or forced air-cooling may be required for continuous power output

Figure 2: VSA Stand Alone Dimensions



6 Electrical Specifications

	Module		Stand Alone		
MODEL	VSA-1530	VSA-2050	VSA-1530-SA	VSA-2050-SA	
Input Voltage	70-340 VDC	70-340 VDC	80-240 VAC Single-Phase Motor bus = AC Input Volts * 1.414		
Output Power					
Peak Current	30	50	30	50	Amps
Peak time	1	1	1	1	Seconds
Continuous current	15	20	15	20	Amps
PWM Outputs	20 kHz center-weighted PWM (Can be factory adjusted)				
PWM Ripple Frequency	40 kHz (Can be factory adjusted)				
Commutation and Control					
Current loop	20 kHz (50 µs period) update rate				
Velocity Loop	4 kHz (250 µs period) update rate				
Position loop	1 kHz (1mS period) update rate				
Commutation	Field Oriented Control (FOC) or Traditional Sinusoidal				
Phase Initialization	Selectable: Hall startup then sinusoidal from encoder Encoder startup, no halls required External 2-phase analog sine input				
Bandwidth	3 kHz typical, varies with load inductance				
Minimum Load Inductance	400uH line to line				
Current Monitor Output					
Output Voltage Range	0-10 VDC				
Scaling	1V = 4 Amps	1V=6 Amps	1V = 4 Amps	1V=6 Amps	
Serial Interface					
Interface Type	RS-232 or USB				
Baud	115k				
Data Format	8 Data bits, No Parity, 1 Stop Bit				
Protocol	ASCII				
Encoder Power Supply Output					
Output Voltage	+5 VDC				
Maximum Output Current	250mA, Internally fused				

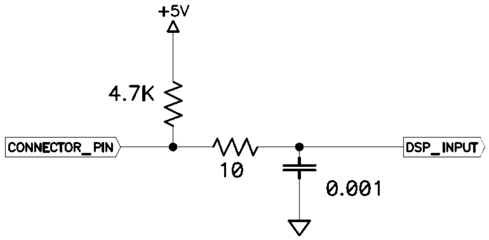
6.1 I/O Interface Drawings

6.1.1 Digital Inputs

The following drawing shows the circuitry for Enable, Reset, Fault and the User I/O pins when configured as inputs.

Fault, Enable, Reset, User1,2,3,4 Configured As Inputs

Input Voltage Range	0-5 VDC
Internal Pull-up	4.7k ohms
Absolute Maximum Voltage	5.5 VDC
Logic High	+2 to +5 VDC
Logic Low	-0.5 to 0.8 VDC
Filter	16MHz

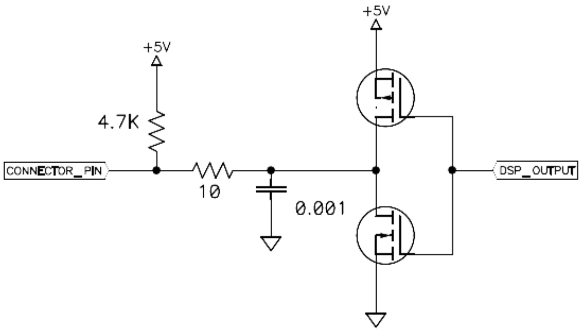


6.1.2 Digital Outputs

The following drawing shows the circuitry for Fault and User I/O pins when configured as outputs.

Fault, User 1,2,3,4 Configured As Outputs

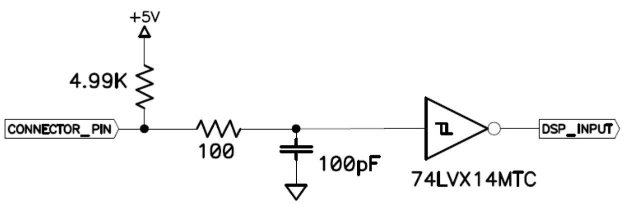
Internal Pull-up	4.7k ohms
High Level Output Current	-10mA
Low Level Output Current	25mA Maximum
High Level Output Voltage	4 VDC



6.1.3 High-Speed Digital Input

The following drawing shows the circuitry for the High-Speed digital input.

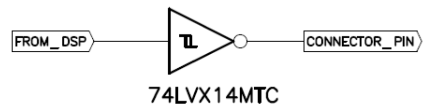
Input Voltage Range	0-5 VDC Schmitt Trigger Input type 74LVX14
Internal Pull-up	4.99k ohms
Absolute Maximum Voltage	7 VDC
Logic High Threshold	+2.2 VDC
Logic Low Threshold	0.9 VDC
Filter	16MHz



6.1.4 Regen Output

The following drawing shows the circuitry for Regen output. This output can be used to control an external relay when the bus voltage exceeds a preset level. The relay should have a dumping resistor connected in a manner that will safely handle the extra voltage.

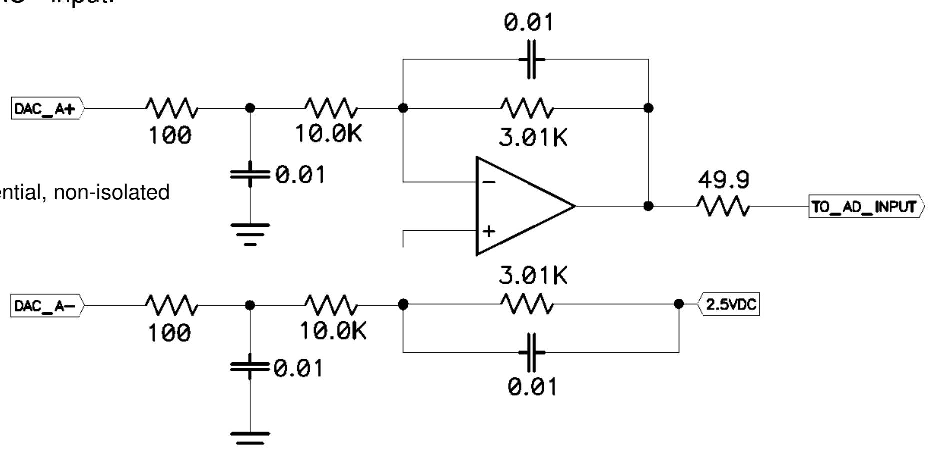
Output Type	Digital
High Level Output Voltage	3 VDC @Ioh = -50uA
Low Level Output Voltage	0.1 VDC @Ioh = -50uA



6.1.5 Analog Inputs DAC A+, DAC A-, DAC B+, DAC B-

The following drawing shows the typical analog input circuitry for the DAC inputs. The inputs are scaled to accept a maximum of +/-10 VDC. For single-ended operation, apply the voltage to the DAC + input and connect the signal ground to the DAC - input.

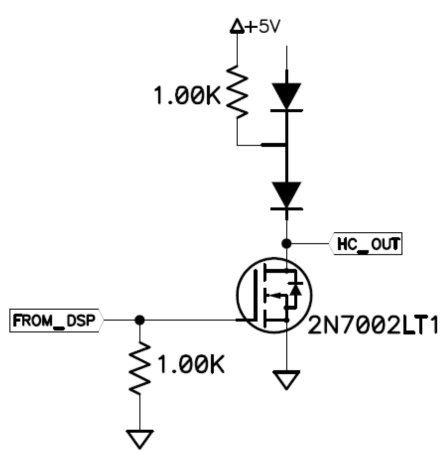
Input Voltage Range	+/-10VDC Differential, non-isolated
Maximum Voltage	+/-10VDC
Input Impedance	10k ohms
Resolution	12-bit



6.1.6 High Current Output

The high current output is a general-purpose output driven by an open drain MOSFET. It can sink up to 500mA of current.

Output Type	Open Drain MOSFET
Internal Pull-up	4.7k ohms
High Level Output Current	-5mA
Low Level Output Current	500mA Maximum
High Level Output Voltage	5 VDC



6.1.7 Encoder Inputs and Outputs

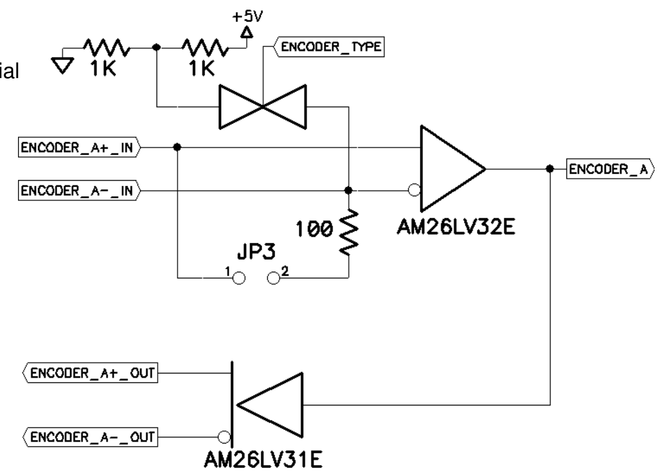
The following drawing shows the typical encoder input circuit. Jumper JP3 controls the encoder load. With the jumpers all in, 100-ohm resistors are place across the encoder inputs as shown. When Encoder Type is set to “S” in software for single ended, the 1K ohm pull up/pull down pair is switched in as shown.
If using JP3, always insert or remove all 3 jumpers at a time. JP3 is located under the cover directly behind the Reset button.

Encoder Inputs A+, A-, B+, B-, I+, I-

Input Type	Single-ended or RS-422 Differential
Single Ended Input Voltage Range	0-5 VDC
Differential Input Voltage Range	+/-5.8 VDC
Absolute Maximum Differential Voltage	+/-12 VDC
High Level Input Voltage	+2 VDC
Low Level Input Voltage	0.8 VDC
Maximum Switching Frequency	25MHz
Input Termination	100 ohms, software configurable

Encoder Outputs A+, A-, B+, B-, I+, I-

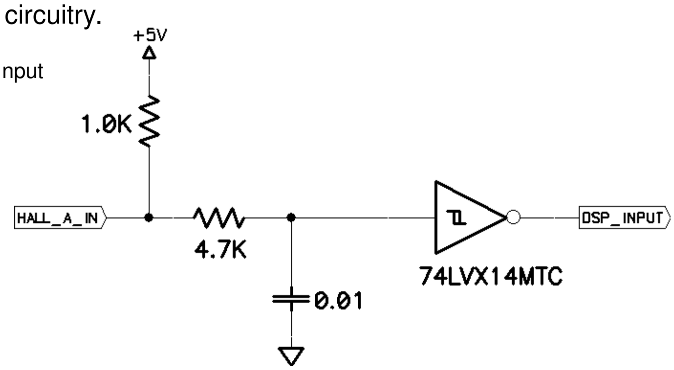
Output Type	RS-422 Differential Line Driver
High Level Output Voltage	3 VDC @Iol=20mA
Low Level Output Voltage	0.2 VDC @Iol=20mA
Differential Output Voltage	2.6 VDC @Rload = 100 ohms
Maximum Switching Frequency	25MHz



6.1.8 Hall Inputs

The following drawing shows the typical hall input circuitry.

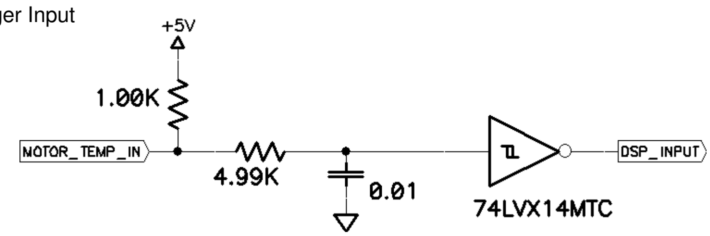
Input Voltage Range	0-5 VDC Schmitt Trigger Input
Internal Pull-up	1k ohms
Absolute Maximum Voltage	7 VDC
Logic High Threshold	+2.2 VDC
Logic Low Threshold	0.9 VDC
Filter	3.3kHz



6.1.9 Motor Temperature Switch Input

The motor temperature switch input is designed to connect to a motor mounted thermal switch, either an PTC or open contact type device. The active level of the fault condition can be set in software.

Input Voltage Range	0-5 VDC Schmitt Trigger Input
Internal Pull-up	1k ohms
Absolute Maximum Voltage	7 VDC
Logic High Threshold	+2.2 VDC
Logic Low Threshold	0.9 VDC
Filter	3.3kHz

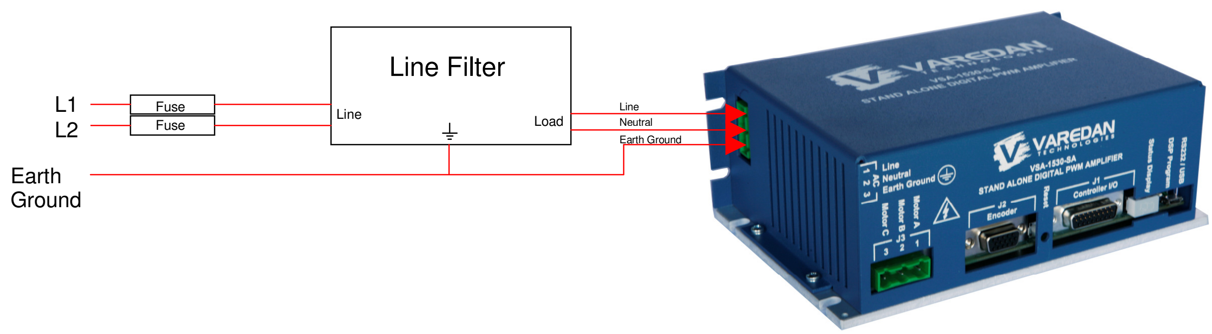


6.2 Stand Alone AC Input Power Wiring

The following drawing shows the recommended connection for the AC input to the stand alone package. Connect the AC mains and earth ground to the appropriate pins on the mating connector and double check the wiring before plugging the mate into the amplifier. The warranty does not cover damage due to improper wiring of the power connector.

DANGER

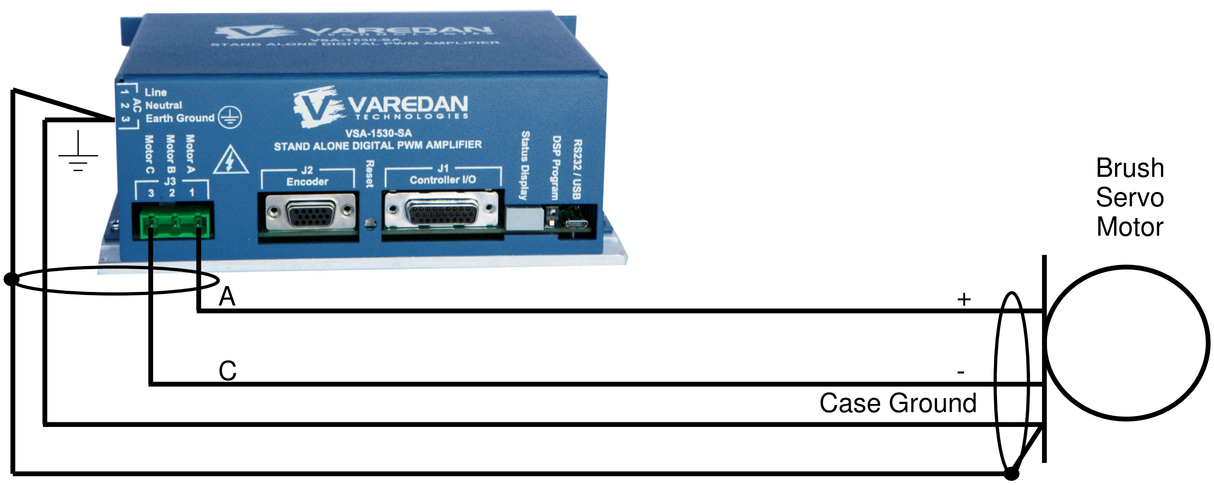
Hazardous voltages are present at the motor output terminals, input power connection, and within the sheet metal enclosure. Disconnect the power source before plugging / unplugging any connections or before servicing or disassembling the enclosure.



6.3 Stand Alone Motor Wiring

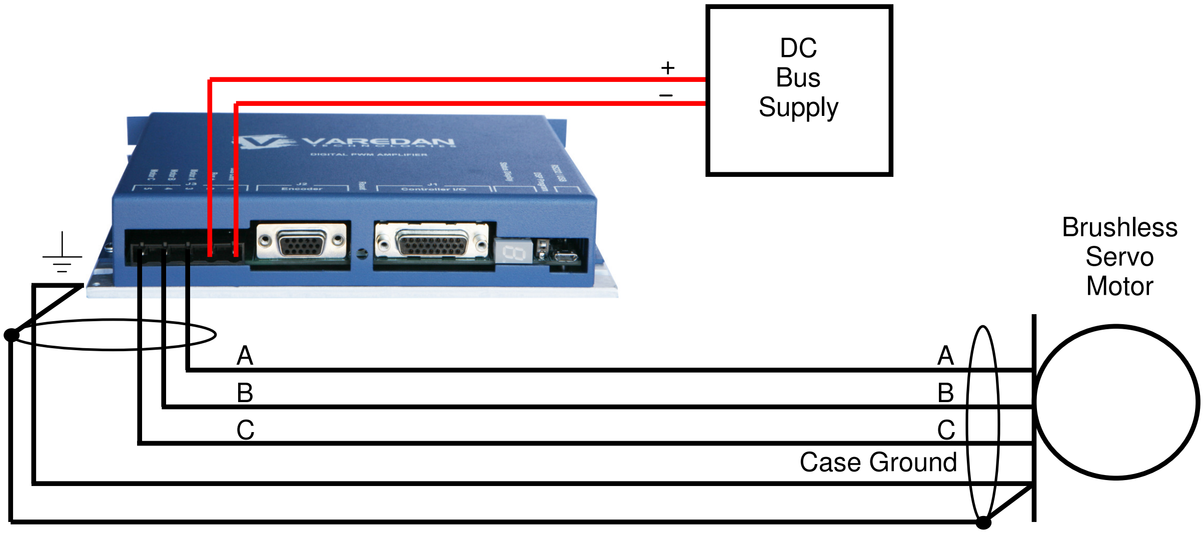
6.3.1 Three-Phase Motor Wiring

6.4 Single-Phase Brush Motor Wiring

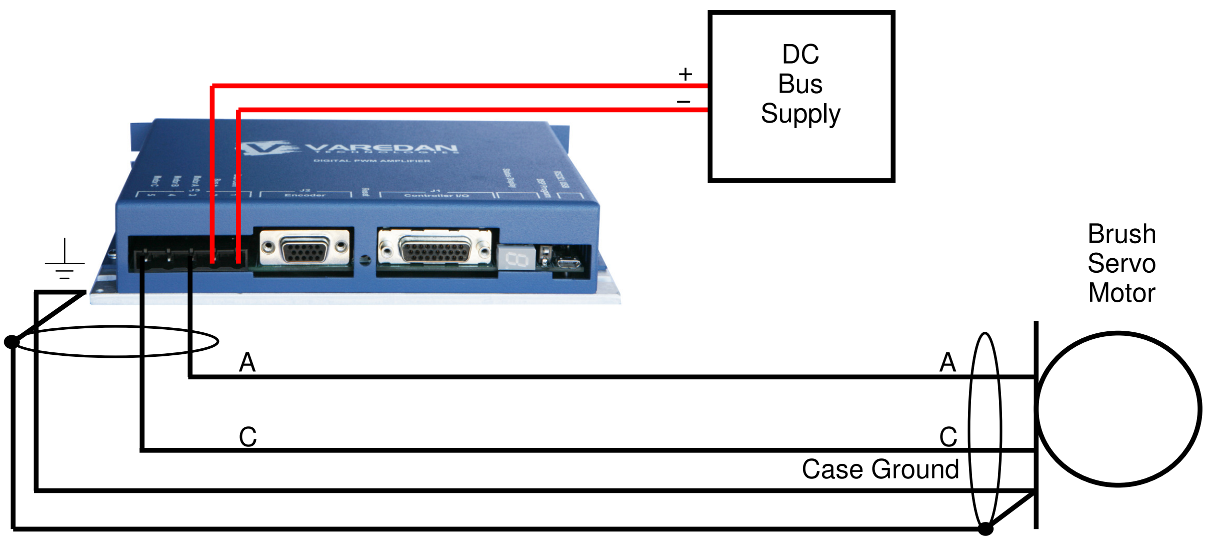


6.5 Module Motor and Bus Connections

6.5.1 Three-Phase Motor and Bus Connections



6.5.2 Single-Phase Motor and Bus Connections



7 Connector Descriptions

7.1 Main Signal Connector

There are 2 different connector options for the main signal connector, a 15-pin Molex or a high density DB-26. The 15-pin Molex is typically used for 2-phase external current mode configurations. The signals for each connector are shown below.

7.1.1 Main Signal Connector, 15-Pin Molex

Type: Molex 22-05-3151

Pin 1

Typical Mate
Molex: 22-01-3157
Digikey: 22-01-3157-ND

Pin	Signal Name	Description
1	DAC A+ Input	+/-10 VDC analog phase A command input
2	DAC A- Input	
3	DAC B+Input	+/-10 VDC analog phase B command input
4	DAC B- Input	
5	No Connect	
6	Digital Ground	Common for logic level inputs and outputs.
7	Current Monitor Output	Analog 0 to 10VDC output scaled to the PKLIMIT setting.
8	Analog Ground	Common for Analog DAC inputs.
9	No Connect	
10	Enable	Logic level input to used to enable the amplifier. Active level is programmable in software.
11	Fault Output	Logic level input from other amplifiers. Active level is programmable in software
12	Digital Ground	Common for logic level inputs and outputs.
13	Reset Input	Logic level input used to reset the amplifier. Active level is programmable in software.
14	Motor Temp Input	Normally Closed thermal switch input from motor
15	No Connect	

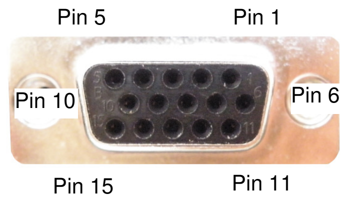
7.1.2 J1 Main Signal Connector DB-26HD

Type: DB-26HD Female

Typical Mate
Norcomp: 180-M26-103L031
Digikey: [180-M2631MN-ND]

Pin	Signal Name	Description
1	Earth Ground	Provides electrical connection to the chassis and heatsink of the amplifier
2	DAC A- Input	+/-10 VDC analog command input used for analog velocity, analog torque, or 2-phase sine input mode
3	DAC A+ Input	
4	Enable Input	Logic level input to used to enable the amplifier. Active level is programmable in software.
5	Reset Input	Logic level input used to reset the amplifier. Active level is programmable in software.
6	User I/O 1	General purpose logic level signals, software programmable as inputs or outputs.
7	User I/O 2	
8	User I/O 3	
9	Fault Output	Logic level input from other amplifiers. Active level is programmable in software
10	DAC B+Input	+/-10 VDC analog command input used for 2-phase sine input mode or as tachometer input in single-phase mode.
11	DAC B- Input	
12	User I/O 4	General purpose logic level signal, software programmable as input or output.
13	High Speed Input	Logic level input used to trigger hardware driven events in software. Can also be used as a general purpose input.
14	Current Monitor Output	Analog 0 to 10VDC output scaled to the PKLIMIT setting.
15	Digital Ground	Common for logic level inputs and outputs.
16	High Current Output	Open drain output with 100mA drive capability. Programmable in software.
17	Analog Ground	Common for Analog DAC inputs.
18	Regen Clamp Output	Logic level signal activated when measured bus voltage exceeds 350VDC.
19	Digital Ground	Same as pin 15.
20	+5VDC Output	+5VDC (200mA limit).
21	Encoder I- Output	Differential outputs driven from motor encoder inputs.
22	Encoder I+ Output	
23	Encoder B- Output	
24	Encoder B+ Output	
25	Encoder A- Output	
26	Encoder A+ Output	

7.2 J2 Motor Feedback Connector



Type: DB-15HD Female

Typical Mate
Norcomp: 180-M15-103L031
Digikey: 180-M1531MN-ND

Pin	Signal Name	Description
1	Earth Ground	Provides electrical connection to the chassis and heatsink of the amplifier
2	+5VDC Output[1]	Provides encoder power, max 200mA.
3	Hall A Input	Logic level input from hall sensors
4	+5VDC Output[1]	Same as pin 2. Total current capacity for both pin 2 and pin 5 is 200mA
5	Digital Ground	Common for logic level inputs and outputs.
6	Hall B Input	Logic level input from hall sensors
7	Encoder I- Input	Differential encoder channel input
8	Encoder I+ Input	
9	Hall C Input	Logic level input from hall sensors
10	Motor Temp. Switch	Logic level or PTC input from motor temperature switch.
11	Encoder B- Input	Differential encoder channel input
12	Encoder B+ Input	
13	Encoder A- Input	
14	Encoder A+ Input	
15	Digital Ground	Common for logic level inputs and outputs.

Notes: 1) +5vdc to J2-2 and J2-4 is internally fused at 250mA.

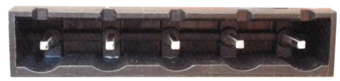
7.3 Motor and Power Connectors

The motor and power connections for the module can be one of three types; plug-in, screw terminal or spring clamp, as shown below. The stand alone uses separate connectors for the motor and power connections as shown in sections 7.3.2 and 7.3.3.

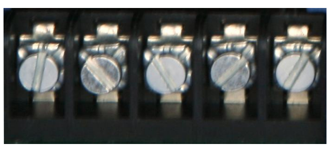
7.3.1 Module Motor and Power Connectors

Various connector options are available for the motor and power connectors for the module. The various choices and their mates are shown below. All variations of connectors have a common pin out.

Type: Amphenol ELFH05410 5-position header, 0.300" spacing.



Typical Mate
Amphenol: ELFP05410
Digikey: APC1188-ND



Screw Terminals

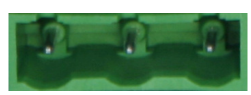
Spring Clamp

Pin	Signal Name	Description
1	Motor Bus Voltage	DC bus voltage - input
2	Motor Bus Voltage	DC bus voltage + input
3	Motor Phase A	Motor phase A connection
4	Motor Phase B	Motor phase B connection
5	Motor Phase C	Motor phase C connection

7.3.2 Motor Connector For Stand Alone Model (Front of Stand Alone Case)

Type: On Shore Technology EDSTLZ960/3

Note pin orientation compared to AC Connector



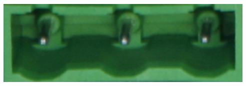
Typical Mate
On Shore Technology: EDZ960/3
Digikey: ED1734-ND

Pin	Signal Name	Description
1	Motor Phase A	Motor phase A connection
2	Motor Phase B	Motor phase B connection
3	Motor Phase C	Motor phase C connection

7.3.3 AC Power Connector For Stand Alone Model (Rear of Stand Alone Case)

Type: On Shore Technology EDSTLZ960/3

Note pin orientation compared to Motor Connector



Pin 1 2 3

Typical Mate
On Shore Technology: EDZ960/3
Digikey: ED1734-ND

Pin	Signal Name	Description
1	Line	AC Line Input
2	Neutral	AC Neutral Input
3	Earth Ground	Chassis Ground

7.4 J4 USB Connection Micro USB-B (optional)

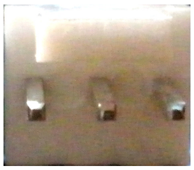
Type: USB Micro-B receptacle

Typical Mate: Standard USB micro-B cable

Pin	Signal Name	Description
1	5VDC	+5VDC from host computer
2	USB Minus	USB communication signals
3	USB Plus	
4	No Connect	
5	Digital Ground	Common

7.5 J5 RS-232 Serial Interface Connector (optional)

Type: Molex: 0022053031 3-position friction lock header.



1 2 3

Typical Mate:
Molex: **0010112033**
Digikey: WM2602-ND

Pin	Signal Name	Description
1	RxD (input)	Rx input. Data from host computer, input to amplifier
2	TxD(output)	Tx input. Data to host computer, output from amplifier
3	Digital Ground	Common

8 Amplifier Input Power Requirements

8.1 Module DC Input Power

The VSA amplifier module requires a single DC input voltage in the range of 70-340 VDC (motor bus voltage) connected to the B+ and B- inputs. All internal voltages are derived from this DC input voltage. Note that B+ and B- are internally isolated.

8.2 Stand Alone AC Input Power

The VSA Stand Alone requires a single-phase AC line voltage input of between 80 and 230 VAC. Note that this connection is to the rear of the case. Do not connect AC power to the J3 motor connector. A non-regulated linear power supply is used to derive the motor bus voltage from the AC line voltage. The following function defines the resulting bus voltage given the AC line voltage:

Motor Bus Voltage (Volts DC) = AC Line Voltage * 1.414

9 User Intefaces

9.1 Serial Interface

The VSA amplifier communicates with a host via a RS232 or USB connection at 115,200 baud.

Any "dumb terminal" serial communications program such as HyperTerminal can be used for communications. The standard settings are **8** data bits, **1** stop bit, **no** parity and **no** hardware or software handshaking.
In HyperTerminal, add a 100mS character delay by using the following steps:
Settings → Emulation = ANSIW. **ASCII Setup** → No boxes checked, 100msec delay,

HyperTerminal Note: When changing baud rates or establishing communication for the first time use the call\disconnect and then call\call tab prior to cycling power to the amplifier.

A very good terminal emulator program can be found here: https://sites.google.com/site/terminalbpp/

That one is a bit more complex than HyperTerminal but it offers many more options and features than Microsoft's version.

9.1.1 RS232 Serial Interface

The amplifier can communicate with a host via RS-232 using a three wire DTE to DTE cross over serial cable as shown below. Note that the J5 RS-232 interface pins (1 & 2) are disabled if the USB port is being used, but the signal pins remain active.

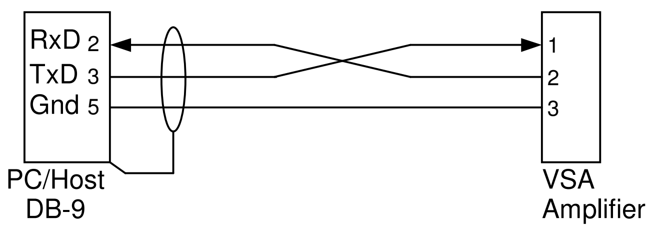


Figure 8: Serial Data Cable Diagram

9.1.2 USB Interface

As an alternative to RS-232, USB can be used for communication. The VSA amplifier accepts a standard USB Type MicroB connector.

The easiest way to use the USB interface is to establish a virtual com port (VCP) using the driver provided by Future Technology Devices, Inc. which can be found at

http://www.ftdichip.com/Drivers/VCP.htm

This driver allows the USB port to be configured as a COM port by the operating system. Application software can access the USB device in the same way as it would access a standard COM port with of the same settings.

Be sure to set the baud rate for the VCP to 115,200 for Normal mode communication. When an active USB cable is plugged into the USB port, the RS-232 communication on J5 is disabled.

9.1.3 Communication Format

Once the host communication program is properly configured and the host cable is connected, apply power to the VSA amplifier. The VSA amplifier should respond with the sign-on message which should look like the following text in the terminal window. When the amplifier is ready to accept a new command, the user prompt character “>” will be shown.

Commands can now be entered. The example below shows the reply from the **CONFIG?** command. It is recommended to confirm the configuration of the amplifier to make sure it matches the motor and the expected running parameters.

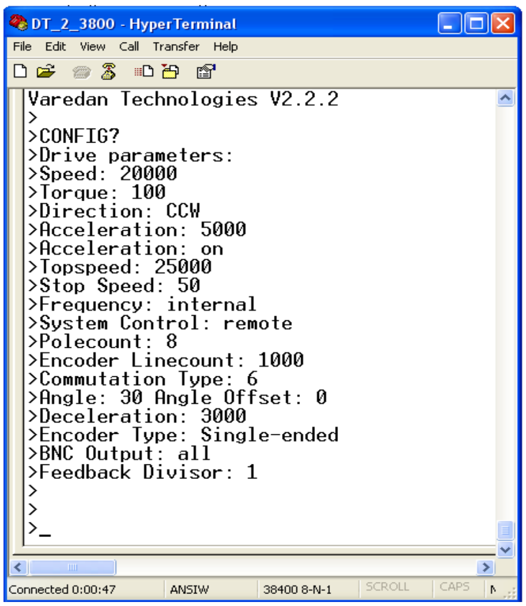


Figure 9: Serial Communications Interface

Once desired parameter values are found, use the WRITE command to save the changes. If a RESET is issued before the WRITE command, any parameter changes will be lost and the amplifier will revert to the last saved set of parameters.

In either RS-232 or USB modes, the following describes the command syntax and amplifier response format:

Commands are entered using ASCII characters from the terminal or serial port. To enter a command with a user entered data field, the command name followed by a “:” or “=” followed by the data for the command, followed by Enter (carriage return) is used. As a minimum, all commands must be terminated by the carriage return character (ASCII 13). The line feed (ASCII 10) is optional and is not used by the amplifier.

A typical command has the following ASCII format. Control characters are shown in <>:

CONFIG?<Cr><Lf>

POLES=4<Cr><Lf>

All characters sent to the amplifier are echoed back. When the amplifier has accepted the command, the prompt “>” is returned. Any invalid commands are ignored and the “Invalid Command” message is sent.

9.2 Pusbutton Switch S1

The pushbutton switch on the front panel (between the Encoder connector and Amplifier I/O connector) is used to reset the amplifier. A quick press and release of the button should result in a full system reset. As the amplifier comes out of reset (or power on), the 7-segment LED display will flash an “8” and then indicate the operating mode as described later in this manual.
If the switch is held in and the power is applied (or cycled), the software version will be displayed character by character on the 7-segment LED display, then the amplifier will enter normal operation. The switch should be released as soon as the version number sequence starts on the LED display.

9.3 Firmware Programming Switch S2 & LED D2

S2 is a toggle switch used to put the DSP into programming mode. When this switch is in the down position and the DSP is reset, the system will enter firmware programming mode and yellow LED D2, which is adjacent to S2, will be on. When the DSP is in this mode normal amplifier operation is disabled.

For normal operation, this switch should be in the up position and LED D2 should be off. If the switch is placed in the down position by accident, place the switch in the up position and reset the amplifier.

Programming mode is used to program the firmware in the DSP using the serial interface. See Appendix B.

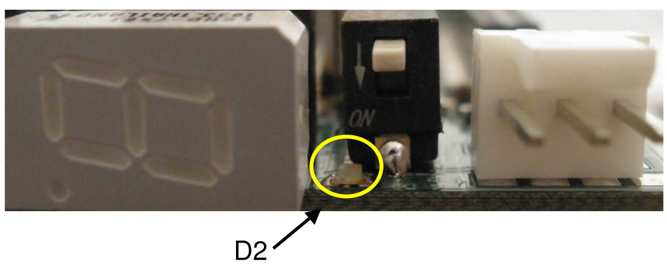
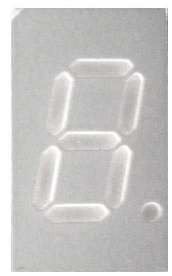


Figure 10. Program switch shown in normal operating position (up) and LED D2 is shown in the off state.

9.4 Status LED

The 7-segment LED display on the front panel shows the status of the amplifier in real-time. The amplifier should display an “8” and then a “C” when first powered or after a reset in the disabled state with no errors. The amplifier should display “0” when enabled. When an error is detected, the amplifier is disabled and an error code is shown on the display.

The following table lists the front panel LED display codes and their meaning. If multiple errors are present, the display will cycle through all the error codes, displaying each for ½ second. Most errors can be reset by either pressing the front panel pushbutton switch or cycling power to the unit. Some errors cannot be fixed in the field. Please contact the factor for assistance with any errors that do not clear after a reset.



LED Code	Description
1	External fault Input is active
2	Non-volatile memory error
3	I²C internal bus error
4	Encoder phase error
5	Not used
6	+/-15v internal bias power supply error
7	Offset reference internal supply error
8	Power on reset (shows briefly following reset)
9	Not used
A	Logic internal power supply error
b	Bus over voltage
C	Disabled (normal message)
c	Checksum memory error (lower case c)
E	Hall error (only active when halls are enabled)
F	PWM over current fault
H	Heatsink over temperature
h	Motor over temperature input active
L	I²T Over current fault
0	Enabled (normal message)
o	Motor over speed (only active in velocity or position mode)
.	Decimal point indicates current is exceeding current limit set point

10 Protection Functions

The amplifier has a number of built-in protective functions that disable the amplifier in the event of a sensed fault. The fault conditions are explained in the following sections.

10.1 I^2T Over Current Protection

This function protects the amplifier and motor in the event of an over current condition. This algorithm closely simulates the heating effect of current through the windings of a motor. The settings for this function are user programmable within the limits of the amplifier and provide protection for both continuous and peak over current conditions over time. This algorithm provides a trip time that is proportional to the amount of over current, so for higher values, the amplifier will trip faster than lower values.

Once the sensed motor current exceeds the CcLimit trip value, the DSP begins accumulating time. If the sensed current remains above the CcLimit value, the amplifier will shut down, or trip, in the amount time based on the following formulas. If the sensed current falls below the CcLimt, the accumulator decreases until it reaches 0. If the amplifier trips due to the timer reaching the time-out value, an I^2T Error (LED code "L") is reported.

The values that determine the limits for over current protection are as follows:
CcLimit = Allowable continuous current limit in amps. Set using the CCLIMIT command.
PkLimit = Allowable peak current limit in amps. Set using the PKLIMIT command.
PkTime = Allowable peak current time duration in seconds. Set using the PKTIME command.

The calculation for I^2T over current is based on 2 equations:

Equation 1: I^2T Limit = ((PkLimit^2 - CcLimit$^{2)}$ * PkTime) in amp^2*seconds
Equation 2: Trip time in Seconds = I^2T Limit / (Sensed Current^2 - CcLimit^2)

Equation 1 is calculated after reset or if any of the above 3 current values are changed
Equation 2 is continually performed using the sensed current to determine if a trip condition exists.

For a given set of over current parameters and sensed current, the trip time can be calculated:

Example:
CcLimit = 5A
PkLimit = 15A
PkTime = 0.5 seconds

If Sensed Current = 18A (Slightly greater than PkLimit so trip time should be less than PkTime)

From Equation 1) **I^2T Limit = (15^{2}A - 5^{2}A) * 0.5 sec $^=$ 100 amp^2 * seconds**

From Equation 2) **Trip Time = 100 amp^2 * seconds / (18^{2}A - 5^{2}A) = 0.344 seconds**

If Sensed Current = 10A

From Equation 2) **Trip Time = 100 amp^2 * seconds / (10^{2}A - 5^{2}A) = 1.33 seconds**

10.2 Internal Protection

The amplifier has multiple internal protective functions that check for error conditions. If an error is found, the amplifier is disabled and the appropriate error code(s) is displayed on the 7-segment LED and reported over the serial interface. The parameters for these internal errors are fixed at the factory and are not user programmable.

LED Error Code	Fault Condition	Description of Fault	Cleared/Corrected By
1	External Fault	External fault input is active	Set Fault input inactive
2	NVM Error	Internal memory error	Reset[1]
3	I2C Error	Internal bus error	Reset[1]
4	Encoder Phase Error	DSP detected illegal encoder state	Reset. Check encoder output and/or wiring and encoder power
5	Not Used		
6	Internal Bias Error	Internal power supply fault	Reset[1]
7	Internal Reference Error	Internal power supply fault	Reset[1]
8	None - Power on reset	Normal, displays briefly after reset	Check reset input or reset switch if stuck on "8"
9	Not Used		
A	Internal Logic Power Error	Internal power supply fault	Reset[1]
b	Bus Over Voltage	External Bus > 340 VDC	Lower bus voltage
d	Disabled	Normal message in disabled state	
c	Checksum	Internal memory error	Reset[1]
E	Hall Error	Hall Sensor inputs are all 1's or 0's (illegal condition)	Check hall wiring and/or hall sensors and encoder power
F	PWM Fault	Internal PWM stage power fault	Reset[1]
H	Amplifier Over Temperature	Heatsink temperature > 70℃	Disable amplifier, provide adequate cooling, reduce current
h	Motor Over Temperature	Motor Temperature switch active	Disable amplifier, use less power, use bigger motor
L	I2T Over Current Fault	Over current trip condition	Reset. Reduce current, change I2T settings
0	Enabled	Normal message in enabled state	
o	Over Speed	Motor speed > Overspeed setting	Reset. Reduce speed. Change Over Speed setting.
.	Decimal Point	I2T Over Current is about to trip	Reduce current, change I2T settings
(blank)	No display	Amplifier may be in firmware update mode	Check programming switch (should be **up** for normal operation). Cycle power.

1 - If a reset or power cycle sequence does not correct error, amplifier maybe damaged and will need to be returned to factory for further troubleshooting and repair.

11 Modes of Operation

This amplifier is basically a device that outputs and controls current (torque in the motor) to its motor phase connections in either a single-phase or three-phase configuration. How that current gets commanded and where the command comes from is determined by the amplifier's mode of operation. In all modes of operation, a "command current" must come from somewhere in the system. Whether the command current comes from an external controller or from inside the amplifier is determined by the mode of operation. The DSP in this amplifier uses this current command to internally close the current loop in each motor phase using pulse-width modulation (PWM) by allowing more or less current to flow through the output transistors.

For modes that use an external command current, the command current can come from one of two sources; the analog DAC input(s) or as a serial command from the user interface.

For modes that generate the current command internal to the amplifier as in the case of velocity or position modes, a higher-level control loop is used to generate the command. For velocity mode, the current command comes from the output of the velocity loop. The command for the velocity loop comes from either the analog DAC input, or as a serial command from the user interface. For position mode, the current command still comes from the velocity loop, but the velocity command now comes from the internal position loop. The position loop command comes from either an external source over the serial interface, or from the internal trajectory amplifier when the amplifier is commanded to move to a specific position.

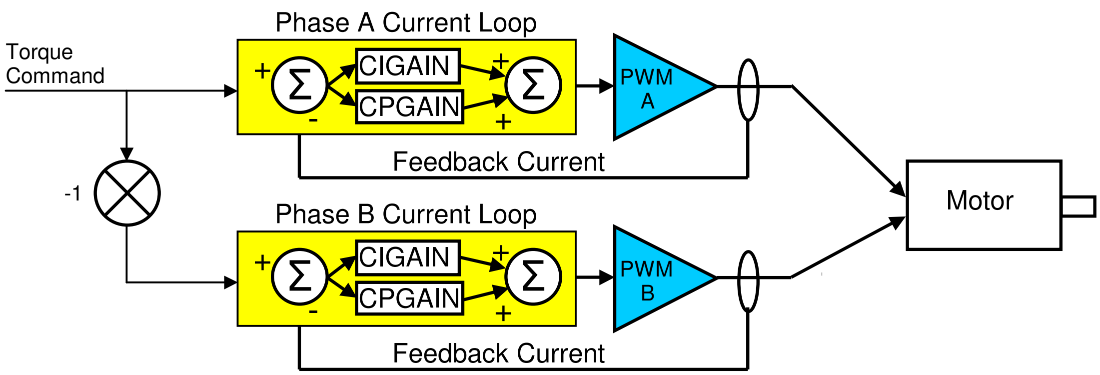
	Operating Mode	Ampmode	Analog Input	Digital Input	Commutation	Velocity Control	Position Control
Single-Phase modes	Single phase mode torque	0	✓	✓			
	Single phase velocity mode	1	✓	✓		✓	
	Single phase position mode	2	✓	✓		✓	✓
Three-Phase modes	2-Phase Sine Mode	3	✓				
	Three phase torque mode	4	✓	✓	✓		
	Three phase velocity mode	5	✓	✓	✓	✓	
	Three phase position mode	6	✓	✓	✓	✓	✓

Each of the modes is explained in detail in the following sections. For each of the modes, the serial commands used to establish the mode of operation are given, followed by the commands that are active in that particular mode.

The command used to establish the operating mode is AMPMODE. Use of this command will be explained in the following sections.

11.1 Single-Phase or Brush Motor Torque Mode

In this mode the output current is proportional to the applied +/-10 VDC analog voltage or serial command current. The amplifier controls the current in phase A with the positive current command value and the current in phase B with the inverse or negative current command value. The current command comes from either an external amplifier or from the open loop OL command over the serial interface.



11.1.1 Single Phase Torque Mode Settings

To put the amplifier in this mode, use the following settings (with the amplifier disabled):
AMPMODE=0

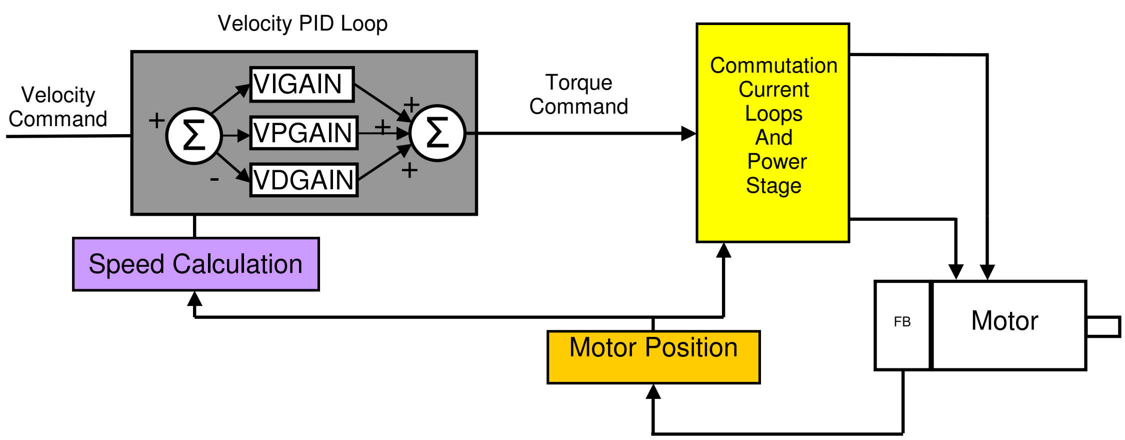
To change the current loop PI parameters, use the following commands:
CPGAIN, CIGAIN, CINTLIMIT

To set the transconductance (volts to amps), use the following command:
ANALOGSCALE=2 (Sets gain for 1 volt input = 2 amps out.)

The amplifier can now be enabled using either the serial command EN or by setting the hardware Enable input active. To use the hardware Enable input and set the active state of the Enable input, use the following commands:

EXTENABLE=1	Use hardware Enable input as source for the amplifier enable
ENABLELEVEL=0	Set the Enable active state to 0 (low for enable)
WRITE	Save these settings in NVM

11.2 Single-Phase Veolcity Mode
In this mode, the amplifier uses either a motor mounted encoder or a tachometer to provide speed control of the motor. The motor speed is controlled by the amplifier's PID velocity loop, which in turn provides the current (torque) command to the current loops. The velocity command can come from either the DAC A analog input in the form of a +/-10 VDC command voltage, where +10v is full scale velocity or from the Speed=x command from the serial interface (x can be any number between 0 and 30000 rpm, depending of course on the motor and encoder or tachometer's capabilities). The direction of rotation for a given input polarity can be set using the CW or CCW commands.



11.2.1 Single-Phase Velocity Mode Settings
To put the amplifier in this mode, use the following settings (with the amplifier disabled):
AMPMODE=1

To change the current loop PI parameters, use the following commands:
CPGAIN, CIGAIN, CINTLIMIT

To change the velocity loop PID parameters, use the following commands:
VPGAIN, VIGAIN, VDGAIN, VINTLIMIT

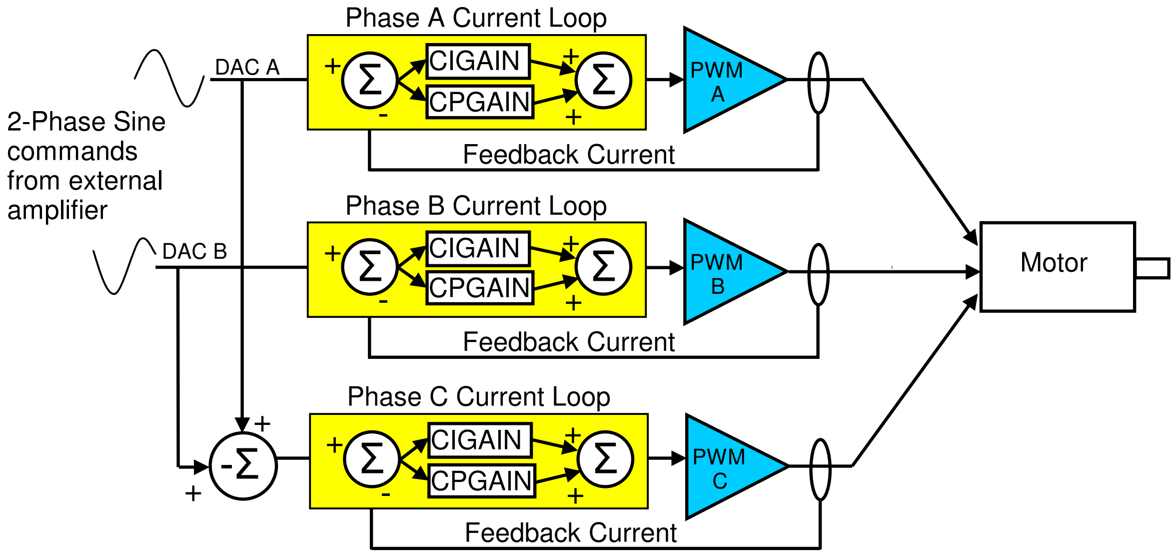
The default input is to use the analog DAC voltage as the velocity command reference. The VELSCALE command sets the relationship of input volts to motor RPM as follows:
VELSCALE=200 (Set gain for 1 volts = 200 RPM, or 10v = 2000 RPM.)

The amplifier can now be enabled using either the serial command EN or by setting the hardware Enable input active. To use the hardware Enable input and set the active state of the Enable input, use the following commands:

EXTENABLE=1	Use hardware Enable input as source for the amplifier enable
ENABLELEVEL=0	Set the Enable active state to 0 (low for enable)
WRITE	Save these settings in NVM

11.3 2-Phase Sine Mode (External Sine Commutation)

In this mode, an external motion controller provides commutation and supplies two current commands (sine waves 120 degrees apart) to the DAC A and DAC B inputs. The amplifier internally generates the current command for the third phase from the negative sum of the supplied phases C = -(A + B). The amplifier closes all 3 current loops internally. The output current is proportional to the applied +/-10 VDC analog voltage. No feedback from the motor to the amplifier is required since commutation is not performed in the amplifier.



11.3.1.12-Phase Sine Mode Settings

To put the amplifier in this mode, use the following settings (with the amplifier disabled):
AMPMODE=3

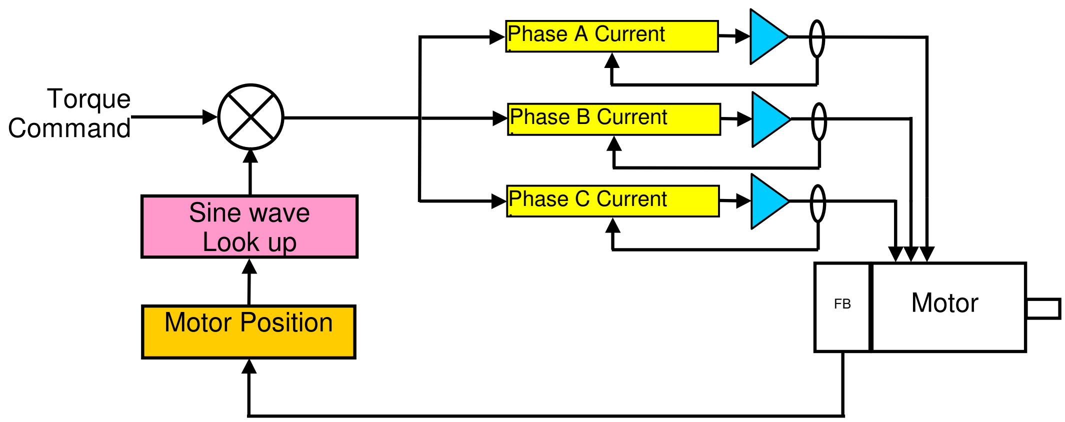
To change the current loop PI parameters, use the following commands:
CPGAIN, CIGAIN, CINTLIMIT

To set the transconductance (volts to amps), use the following command:
ANALOGSCALE=2 (Sets gain for 1 volt input = 2 amps out.)

The amplifier can now be enabled using either the serial command EN or by setting the hardware Enable input active. To use the hardware Enable input and set the active state of the Enable input, use the following commands:

EXTENABLE=1	Use hardware Enable input as source for the amplifier enable
ENABLELEVEL=0	Set the Enable active state to 0 (low for enable)
WRITE	Save these settings in NVM

11.4 Three-Phase Torque Mode
In this mode, the amplifier uses the motor's encoder to provide commutation. The current in the motor is controlled by the amplifier's PI current loops and is proportional to the current (torque) command. The torque command can come from either the DAC A analog input in the form of a +/-10 VDC command voltage, where +10v is full scale (peak) positive current or from the OL=x command from the serial interface (x can be any number between 0.00 and 10.00 representing an equivalent input voltage).



11.4.1 Three-Phase Torque Mode Settings
To put the amplifier in this mode, use the following settings (with the amplifier disabled):
AMPMODE=4

Setup the motor and encoder parameters:
ENCODERCOUNT= 1000 Setting for 1000 line encoder
ENCODERTYPE=S Single ended encoder
POLES=4 Four pole motor

To change the current loop PI parameters, use the following commands:
CPGAIN, CIGAIN, CINTLIMIT

The default input is to use the analog DAC voltage as the torque command reference. To use the open loop software value, use the OL command with the equivalent DAC voltage as the data.
Example: OL=2.55 Sets the torque command to 2.55 volts, causing 2.55 amps to go to the motor.

To set the transconductance (volts to amps), use the following command:
ANALOGSCALE=2 (Sets gain for 1 volt input = 2 amps out.)

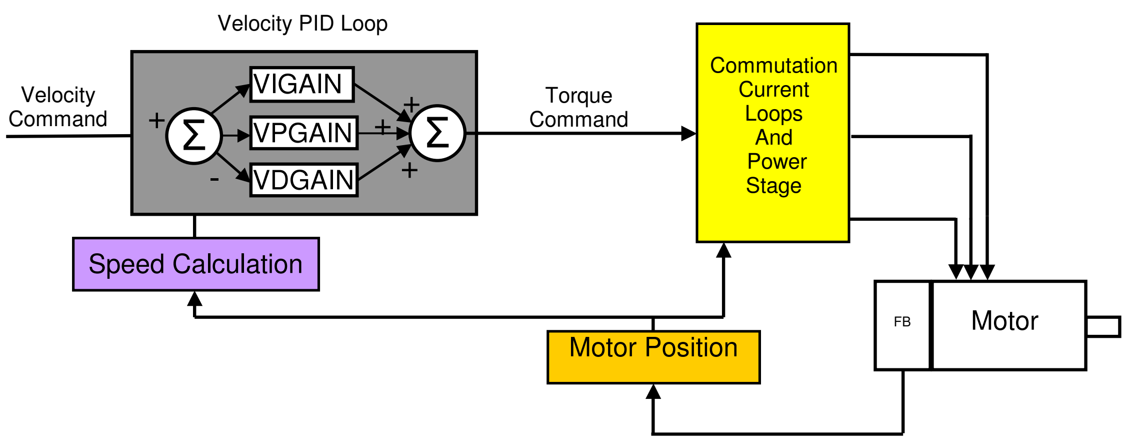
The amplifier can now be enabled using either the serial command EN or by setting the hardware Enable input active. To use the hardware Enable input and set the active state of the Enable input, use the following commands:

EXTENABLE=1 Use hardware Enable input as source for the amplifier enable
ENABLELEVEL=0 Set the Enable active state to 0 (low for enable)

WRITE Save these settings in NVM

11.5 Three-Phase Veolcity Mode

In this mode, the amplifier uses the motor's encoder to provide commutation and speed control. The motor speed is controlled by the amplifier's PID velocity loop, which in turn provides the current (torque) command to the current loops. The velocity command can come from either the DAC A analog input in the form of a +/-10 VDC command voltage, where +10v is full scale velocity or from the Speed=x command from the serial interface (x can be any number between 0 and 30000 rpm, depending of course on the motor and encoder capabilities). The direction of rotation for a given input polarity can be set using the CW or CCW commands.



11.5.1 Three-Phase Velocity Mode Settings

To put the amplifier in this mode, use the following settings (with the amplifier disabled):
AMPMODE=5

To change the current loop PI parameters, use the following commands:
CPGAIN, CIGAIN, CINTLIMIT

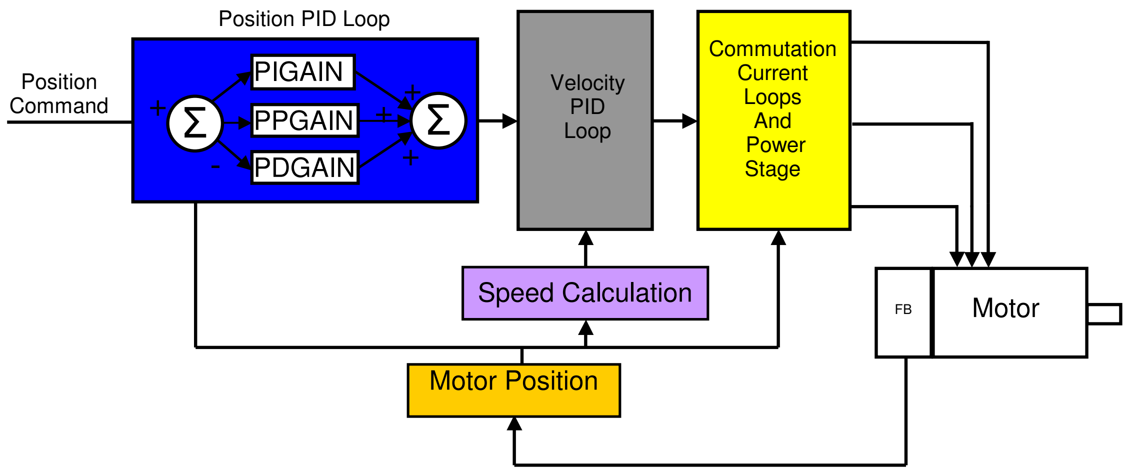
To change the velocity loop PID parameters, use the following commands:
VPGAIN, VIGAIN, VDGAIN, VINTLIMIT

The default input is to use the analog DAC voltage as the velocity command reference. The VELSCALE command sets the relationship of input volts to motor RPM as follows:
VELSCALE=200 (Set gain for 1 volts = 200 RPM, or 10v = 2000 RPM.)

The amplifier can now be enabled using either the serial command EN or by setting the hardware Enable input active. To use the hardware Enable input and set the active state of the Enable input, use the following commands:

EXTENABLE=1	Use hardware Enable input as source for the amplifier enable
ENABLELEVEL=0	Set the Enable active state to 0 (low for enable)
WRITE	Save these settings in NVM

11.6 Three-Phase Position Mode
In this mode, the amplifier uses the motor's encoder to provide commutation and position control. The motor position is controlled by the amplifier's position PID loop, which in turn provides the velocity command and current (torque) commands to the internal loops. The position command comes from the serial interface in the form of a GOTO=x command. The internal trajectory generator provides the ramping and velocity control during the move. Once the motor reaches the end position, the motor holds within +/-1 encoder count at that position.



11.6.1 Three-Phase Position Mode Settings
To put the amplifier in this mode, use the following settings (with the amplifier disabled):
AMPMODE=6

To change the current loop PI parameters, use the following commands:
CPGAIN, CIGAIN, CINTLIMIT

To change the velocity loop PID parameters, use the following commands:
VPGAIN, VIGAIN, VDGAIN, VINTLIMIT

To change the position loop PID parameters, use the following commands:
PPGAIN, PIGAIN, PDGAIN, PINTLIMIT

WRITE Save these settings in NVM

The amplifier can now be used to position the motor using the GOTO=x command, where x = the deisred position.
GOTO=1000 Moves to position 1000 and holds position

11.7 Three-Phase Commutation Phase Finding

For three phase modes (torque, velocity and position), the motor will perform an initial phase finding when first enabled. The type of algorithm used for the phase finding is determined by the TYPE=n command. When n is set to 6, the amplifier uses the motor mounted halls to determine the initial phasing for the motor, and then switches over to full sine commutation after the first hall transition. Using Type 6 mode will result in no motor movement other than what's commanded.

When n is set to 7, the amplifier requires only the encoder (no halls) for commutation. The downside is that there is movement of the motor during this phase finding sequence. This phase finding sequence is only performed once after power on reset. The value for COMCURRENT is used to determine the amount of current to apply to the motor to perform the initial phase finding.

11.8 Three Phase Mode Modulation

When using sinusoidal commutation modes (Amp modes 4, 5 and 6), the user can select the type of PWM modulation performed by the DSP. The 2 choices are Space Vector (a.k.a. Field Oriented Control FOC) or Traditional Sinusoidal. The SVENABLE command selects which type is used.

11.8.1 Space Vector or Field Oriented Control

Space vector modulation is a PWM control algorithm used for multi-phase AC generation (as in the case of driving brushless servo motors), in which the available bus voltage is used more efficiently than traditional sinusoidal PWM modulation.

In the space vector PWM technique, there is 15% gain in motor voltage as compared to traditional analog sinusoidal PWM. There is also a reduction in the harmonics generated by the output devices due the switching methods used. What this means is that for a given bus voltage, the motor will be able to run faster using FOC modulation.

While the resulting current control is sinusoidal, the motor voltages are non-sinusoidal and will have a “flattened” top when displayed on an oscilloscope.

11.9 Traditional Sinusoidal Modulation

With traditional sinusoidal modulation, motor voltages are controlled on an individual basis using a look up table with stored sine values. This technique results in smooth motor movement across the whole speed range. The disadvantage is that it uses the motor bus voltage less efficiently than with space vector modulation.

We make this modulation scheme available in our amplifiers for those system designers that have always used sinusoidal modulation and do not want to change to space vector modulation.

12 Running A Program From Internal Memory

This amplifier has the ability to store commands in internal memory (also saved to NVM) and execute those commands as a stored program from either hardware inputs, or from the terminal interface.

Most all commands can be stored for execution in this program mode. There are some dedicated commands only used to interface with this mode and cannot be stored.

The programming commands are LOADPRG (load program), RUNPRG (run program), LABEL (define a branching label), LOOP (perform a loop back to a label n times), LISTPRG (list program) and END to end programming.

This mode has special prompt "*" character different from the immediate mode prompt ">" to identify when this mode is active.

To enter programming mode (and not execute commands immediately, but store them in memory for later execution), type the command LOADPRG. The "*" character should now be the prompt on the screen. Commands can now be entered in desired execution order. Once the program entry is complete, type the command "END". The ">" immediate prompt should now be shown on the active line. To save the program, type WRITE just as with all other commands this command saves the program to NVM for recall on power up.
Here is a programming example (comments are shown in () and are not entered):

```
>LOADPRG  (start program mode)
*GOTO:0      (Goto position 0)
*LABEL:1     (Define label 1)
*GOTO:1000 (Goto position 1000)
*WAIT:500     (Wait 500mS)
*GOTO:-10000 (Goto position -10000)
*WAIT:200     (Wait 200mS)
*LOOP:1:25     (Loop to label 1 25x. All commands between here and Label 1 will be executed 25 times)
*END              (End programming mode and return to immediate mode)
>
```

The best way to handle programming development is to create the program in an ASCII editor such as Notepad or Word and save the file as a .txt. Then download the program to the amplifier using a text transfer protocol such as HyperTerminal Send Text. The LOADPRG command should be the first command in this file. The END command should be the last command, or WRITE can be used at the end of the file to automatically save the program.

To run the stored program, type the command RUNPRG. The program runs from the first command through the END command. If at any time the program needs to be aborted, type the Escape character (ESC key on top left of most keyboards).

13 Command List

The following commands can be entered over the serial interface and are not case sensitive. When a string of n's (nnnnn) are shown the data is an integer value. When a string of f's (ffff) are shown the data is a floating point value. When a string of c's (ccc) are shown, a character value is required (ex: HALLS:ABC). For numeric values, the user interface does not care if more or less characters are entered. Leading "0's" on numbers are not needed. Not all commands apply to all operating modes. Note: The ":" and "=" can be used interchangeably to separate a command from the input parameter data.

ACCEL:nnnnn Set this value to the desired acceleration rate in RPM/sec with a range from 1 to 40000 RPM/Sec.

ACCEL? Replies with the currently set acceleration rate in RPM/sec

ALARMRESET Resets faults in the amplifier.

AMPMODE:n Sets the operating mode of the amplifier. Amplifier must be disabled to change modes.

AmpMode	Description
0	Single-phase current mode
1	Single-phase velocity mode
2	Single-phase position mode
3	Three-phase external commutation mode
4	Three-phase current mode
5	Three-phase velocity mode
6	Three-phase position mode

AMPMODE? Display the mode setting.

ANALOGIN Sets the analog input as the command source for torque or velocity modes. The External Enable Input is used to enable the system. CW and CCW control the rotation direction for the sign of the input voltage. The default is CW for a positive analog input voltage.

ANALOGOUT Disables the analog input as the command source.

ANALOGAO:f Offset value for analog A input. The floating-point range of f is -1 to 1.

ANALOGBO:f Offset value for analog B input. The floating-point range of f is -1 to 1.

ANALOGSCALE:f.f Used to scale the transconductance (volts in to amps out) for torque modes. Default is 1 for 1VDC = 1Amp. The floating-point range is 0 – 10 (volts per amp). Ex. ANALOGSCALE= 2.0 sets the scaling to 1 volt in = 2 amps out.

ANGLE:nnn Sets the motor commutation angle from 1 – 359 degrees. Also see OFFSET.

ATPOS? Replies with YES if the motor is at the commanded position, NO otherwise.

ATSPDLVL:n Sets the active state for the At Speed Output. Range is 0 or 1.

ATSPD? Replies with YES if the motor is running within the at speed range. Also see the LOKDLY and ATSPDLVL commands.

CCLIMIT:nn Sets the allowable continuous motor current. Range is 0 to continuous rated current, depending on model. When the sensed motor current exceeds this setting, the over current protection algorithm begins timing for a trip.

CCW Sets the commanded spindle direction to Counter-Clockwise. For analog input modes this command will set the spindle direction to CCW for a positive input voltage.

CDGAIN:nnnn Current loop derivative gain. Range is 0-32767.

CIGAIN:nnnn Current loop integral gain. Range is 0-32767.

CPGAIN:nnnn Current loop proportional gain. Range is 0-32767.

CINTLIMIT:nnnnnn Current loop Integration gain limit. 0 – 500,000. Used to “shape” the initial current profile. A lower value will “roll on” the current while a higher value will be more “snappy.

CL Sets closed loop mode. (Only needed if OL is used for Open Loop).

COMCURRENT:nn Sets the commutation current when using Type=7. Range is 0-10 (amps).

COMMUTATION? Replies with a 6 (Hall Mode) or a 7 (Encoder / Sine) representing the presently set commutation mode.

CONFIG? Replies with a brief listing of the amplifier configuration. Note: This is a legacy command. Please use the DUMPALL command to view all parameters.

```
Drive parameters:
Speed: 5000
Torque: 100
Direction: CW
Acceleration: 5000
Acceleration: on
Top speed: 25000
Stop Speed: 10
Frequency: internal
System Control: remote
Polecount: 8
Encoder Linecount: 1024
Commutation Type: 7
Angle: 0 Angle Offset: 0
Deceleration: 2000
Encoder Type: Differential
BNC Output: all
Feedback Divisor: 1
```

CW Sets the commanded spindle direction to Clockwise. For analog input modes this command will set the spindle direction to CW for a positive input voltage.

DECEL:nnnnn Set this value to the desired deceleration rate in RPM/sec with a range from 1 to 40000 RPM/Sec.

DEFAULTS

Do not use this command unless instructed to do so by the factory.
<u>Important calibration values are cleared by this command.</u>

Sets the factory defaults for all parameters as shown below. Note that the Ampmode is set to 2-phase sine after executing this command. Values are NOT saved to NVM after this command is issued.

ACCEL=3000	(set acceleration to 3000 rpm/s^2)
AMPMODE=4	(2-phase sine mode)
ANALOGOUT	(disable analog command)
ANALOGSCALE=1	(set analog input scaling to 1v)
ANGLE	(phase advance angle = 0)
ATSPDLVL=0	(set At Speed Level output to 0 for active state)
CCLIMIT=4	(set continuous current limit to 4 amps)
CDGAIN=0	(set current loop d gain = 0)
CIGAIN=10	(set current loop i gain = 10)
CINTLIMIT=1000	(current loop integrator limit=1000)
CPGAIN=10	(set current loop p gain =10)
CW	(default run direction for + command)
DECEL=3000	(set acceleration to 3000 rpm/s^2)
DISFAULTS=FFF0	(mask encoder phasing, overspeed, motor overtemp and hall faults)
ENABLELEVEL=0	(set active enable level to 0)
ENCODERCOUNT=1000	(set encoder line count to 1000 lines)
ENCODERTYPE=S	(Single-ended encoder)
EXTENABLE=0	(disable external enable input)
JERK=0	(disable jerk)
MAPIO0=0	(map user I/O 0 as input)
MAPIO1=0	(map user I/O 1 as input)
MAPIO2=0	(map user I/O 2 as input)
MAPIO3=0	(map user I/O 3 as input)
MINSPDOUT	(disable minimum external frequency clock speed)
NOSWAP	(disable internal swapping of encoder channels)
OFFSET=0	(hall offset angle = 0)
OVERSPEED=21000	(set overspeed fault to 21000 rpm)
PDGAIN=9	(set position d gain = 9)
PIGAIN=200	(set position i gain = 200)
PKLIMIT=10	(set peak current limit to 10 amps)
PKTIME=1	(set peak current time to 1 second)
POLES=4	(set motor poles=4)
PPGAIN=200	(set position p gain = 200)
RAMPIN	(enable internal trajectory generator)
SPEED=1000	(set target run speed to 1000 rpm)
STOPS=1	(set stop speed to 1 rpm)
TOPSPEED=5000	(set topspeed limit to 5000 rpm)
TORQUE=100	(set maximum allowed motor torque to 100%)
TYPE=7	(Encoder startup commutation)
VDGAN=0	(set velocity d gain = 0)
VIGAIN=10	(set velocity i gain = 10)
VINTLIMIT=1000	(velocity loop integrator limit=1000)
VPGAIN=10	(set velocity p gain =10)
ZSPDLVL=1	(set Zero Speed Level output to 1 for active state)

DIR?	Returns the actual motor direction as "CW" or "CCW".
DIS	Disables the amplifier (kills motor power). No deceleration is performed.
DISABLE	Same as DIS.
DISFAULTS:nnnn	Creates a bit mask for maskable faults within the amplifier. See DISFAULTS? for the bit definitions.
DISFAULTS?	Displays the DISFAULTS value and lists the enable/disable state for each fault.

A "1" in a bit position indicates a fault is disabled.

Bit	Fault
0	Motor Over Temperature
1	Hall Sequence
2	Over Speed
3	Encoder Phasing
4	NVM (internal non-volatile memory)
5	Internal Logic Power Supply
6	Bus Over Voltage
7	ROM Checksum
8	I2C (Over Current Fault)
9	External Error (Fault Input Active)
10	PWM Fault (Internal Power Stage)
11	Amplifier Over Temperature
12	Instantaneous Over Current
13	Reserved
14	Reserved
15	Reserved

Note that the amplifier does not allow all errors to be masked. The following bits are always set to 0 by the amplifier: Bits 11, 10, 7, 5, and 4.

DUMPALL	Lists all parameter names and settings in a format that can be copied and saved into a text file for amplifier backup. See appendix A for more information on the data. **Note: The data shown by this command will vary depending on the Ampmode setting**. Only data that pertains to the selected operating mode will be shown.
EN	Enables the motor and accelerates to the commanded speed set by the SPEED command. If the motor is not commutated, commutation is performed before accelerating based on the TYPE setting.
ENABLE	Same as EN.
ENABLE?	Returns the enabled state as either "ENABLED" or "DISABLED".
ENABLELEVEL:n	Sets the active level for the External Enable Input to 0 or 1. Range is 0,1.
ENCODERCOUNT:nnnnn	Set the encoder line count. Range is 256 to 16384.

ENCODERTYPE:c Set the encoder electrical type as either “S” for single ended, or “D” for differential.

END Program mode instruction used to terminate program entry and indicate the end of a stored program.

EXTENABLE:n Configures the amplifier to use the external enable input. Setting this value to “1” enables the external enable input as the enable source. A setting of “0” disables the external input as the enable source.

FAULT? Displays either “FAULT” if any faults are present, or “OK” if no errors.

FAULTS? Lists any faults present in the amplifier, otherwise returns “No Faults”

FINDINDEX Performs initial finding of the encoder index mark. The amplifier is put into position mode and moves at the programmed JOGSPEED until the encoder index input toggles. The amplifier then positions on this mark and remains holding position at the index location. The position counter can be reset using the POS:0 command to record this as the 0 position (or whatever other position is desired). Future moves to this position will place the motor on the index.

FLT? Displays faults as a bit encoded binary word.

FLTA? Displays faults as a bit encoded ASCII word.

GAINS? Lists the gain settings. The displayed data depends on the operating mode.

```
CPGAIN: 4000
CIGAIN: 1000
CDGAIN:100
CINTLIMIIT:50000
VPGAIN:2000
VIGAIN:500
VDGAIN:0
VINTLIMIT:20000
PPGAIN: 50
PIGAIN: 100
PDGAIN: 100
PINTLIMIT:100000
```

GOTO:nnnn Position command. Motor moves to position nnnn. Range is +/- 2^31. Also see the **STOPHOLD** command.

HALLS:ccc Used to set the hall relationship to the motor phases. Has same action as swapping the hall wires. Example HALLS:ABC or HALLS:ACB.

HALLS? Returns the present hall state. Can be used for troubleshooting hall connections.

HELP Lists the available commands.

I? Lists the phase currents, one per line.

IL? Lists the phase currents all on one line.

INDEXSTOP:n

Enables (n=1) or disables (n=0) stopping on the encoder index mark in velocity mode (Ampmode:5) when a STOP command is issued. To properly use this function, the FINDINDEX command must first be executed at startup. When the STOP command is issued from velocity mode, the amplifier decelerates using the programmed DECEL value, then automatically enters position mode and performs a position move using the JOGSPEED to the position recorded with the FINDINDEX command. The amplifier is held enabled at this position once the index mark is found. To return to velocity mode for another move, issue a DISABLE followed by AMPMODE:5 followed by ENABLE.

INPUTS?

Returns a binary word that is bit encoded with the state of the inputs.

bit 0 = Fault (LSB)
bit 1 = Enable
bit 2 = Ext. Reset
bit 3 = User1
bit 4 = User2
bit 5 = User3
bit 6 = User4
bit 7 = Reserved
bit 8 = Hall A
bit 9 = Hall B
bit 10 = Hall C
bit 11 = Motor Temp Switch
bit 12 = Push Button Reset
bit 13 = High Speed Input
bit 14 = Reserved
bit 15 = Reserved (MSB)

INPUTSA?

Returns an ASCII list of the state of the inputs as follows:

Fault =0
Enable=0
User1=1
User2=1
User3=1
User4=0
Hall A=1
Hall B=0
Hall C=1
Motor Temp=1
(Example data shown). If a particular i/o is mapped as an output, the message Userx=Output is shown instead of a logic state.

JERK

Sets the amount of S-curve ramping for accel or decel. Range is 0-2000000.

JERK?

Displays the calculated S-curve ramp values.

JOGSPEED:nnnnn

Sets the speed in RPM used for a position move (Ampmode:6).

LABEL:n

Program mode command used to mark a position in program memory for branching. The range of values for n is 1-99.

LINEAR

In position mode (Ampmode:6), sets the position counter to allow for +/-2^31 counts. See Rotary command for rotary mode operation.

LISTPRG

Lists any program that resides in memory.

LIMPLEVEL:n

Sets the active level for the Limit+ input. Range of n is 0 or 1. Note: If both limits are active the amplifier will inhibit motion in both directions. To resolve this, set the level to the opposite value or disable the limit using the MAPIO3 or MAPIO4 command.

LIMMLEVEL:n

Sets the active level for the Limit- input. Range of n is 0 or 1.

LOADPRG

Command to enter programming mode.

LOOP:x:y

Program mode command used to branch to label x (previously defined using LABEL command) y number of times. Range for x is 1-99, range for y is 1-9999.

MAPIO1:x

Configures I/O pin 1 as either an input or one of 7 possible output configurations as shown by the following choices for x.

Value of x	Pin Configuration/Function Description
0	Digital Input
1	Run input for program execution. Same as RUNPRG command.
2	Fault output - indicates fault state as 0=no fault, 1=fault
3	At Speed output - 1=at programmed speed, 0=not at speed
4	Zero Speed output - 1=velocity is 0, 0=velocity > 0
5	I^2T Accumulating - 1=current is above I2T settings
6	At position. Position mode at commanded position.

Example: MAPIO1:2 maps I/O #1 as the fault output

MAPIO2:x

Configures I/O pin 2 as either an input or one of 8 possible output configurations as shown by the following choices for x.

Value of x	Pin Configuration/Function Description
0	Digital Input
1	General purpose output. Set state using SetOutputn command
2	Fault output - indicates fault state as 0=no fault, 1=fault
3	At Speed output - 1=at programmed speed, 0=not at speed
4	Zero Speed output - 1=velocity is 0, 0=velocity > 0
5	I^2T Accumulating - 1=current is above I2T settings
6	At position. Position mode commanded position
7	Stop Input. Stops motor using preset deceleration value

MAPIO3:x

Configures I/O pin 3 as either an input or one of 7 possible output configurations as shown by the following choices for x.

Value of x	Pin Configuration/Function Description
0	Limit + Input. Inhibits movement in + direction (CW)
1	General purpose output. Set state using SetOutputn command
2	Fault output - indicates fault state as 0=no fault, 1=fault
3	At Speed output - 1=at programmed speed, 0=not at speed
4	Zero Speed output - 1=velocity is 0, 0=velocity > 0
5	I^2T Accumulating - 1=current is above I2T settings
6	At position. Position mode commanded position

MAPIO4:x Configures I/O pin 4 as either an input or one of 7 possible output configurations as shown by the following choices for x.

Value of x	Pin Configuration/Function Description
0	Limit - Input. Inhibits movement in - direction (CCW)
1	General purpose output. Set state using SetOutputn command
2	Fault output - indicates fault state as 0=no fault, 1=fault
3	At Speed output - 1=at programmed speed, 0=not at speed
4	Zero Speed output - 1=velocity is 0, 0=velocity > 0
5	I^2T Accumulating - 1=current is above I2T settings
6	At position. Position mode commanded position

NOSWAP Disables encoder channel swap.

OFFSET:nn Sets the commutation offset angle.. For CW operation, this value is added to ANGLE. For CCW operation, this value is subtracted from ANGLE. Range is 0-90.

OL:f.fff Sets open loop mode and DAC voltage. Range is 0.000v to 5.000v

OSPD:nnnnn Same as OVERSPEED.

OVERSPEED:nnnnn Sets the speed in RPM for an overspeed fault condition. Range is 1 to 50000.

PKLIMIT:nnn Sets the allowable peak motor current in amps for the I2T protection. Range is 0 to peak rated current, depending on model. This value is also used to scale the analog current monitor output voltage. This monitor voltage is scaled using the following relationship: 0-10vdc = 0 to 100% of PKLIMIT.

PKTIME:f.ff Sets the time out value for the I2T protection. Range is 0-9.99 seconds

POLES:nn Sets the number of mechanical motor poles.

POLES? Responds with the motor pole setting.

POS:nnnnn Sets the position counter. Range is +/-2^31.

POS? Returns the encoder position counter value.

PDGAIN:nnnnn Sets the positioning mode derivative gain. Range is 0 to 32767.

PIGAIN:nnnnn Sets the positioning mode integral gain. Range is 0 to 32767.

PINTLIMIT:nnnnnn Position loop Integration gain limit. Range is 0 – 500,000.

PPGAIN:nnnnn Sets the positioning mode proportional gain. Range is 0 to 32767.

RAMPIN Enables the acceleration and deceleration ramping as set by the ACCEL, DECEL and JERK values.

RAMPOUT Disables programmable ramping. Sets the ramps to 10000 RPM/Second.

READ Reads the stored NVM values for all parameters.

READY? Responds with "YES" when the amplifier is ready, "NO" otherwise.

RESET Resets the amplifier.

ROTARY In position mode (Ampmode:6), sets the position counter to reset every revolution. Position range is 0 to encoder line count x 4. See Linear command for linear mode operation.

RUN Same as EN and ENABLE. Not the same as RUNPRG

S? Replies with the binary value of the 16-bit status flags. Also see SA?

SA? Replies with the hex ASCII value of the 16-bit status flags. Also see S?

Status Flags: (Bit 0 is lsb at far right of displayed value)

Bit	Flag	Description
0	ENABLE	Enabled=1, Disabled=0
1	READY	Ready=1, Not Ready=0
2	COMMUTATED	Commutated=1, Not commutated=0
3	ZERO SPEED	At 0 speed=1, otherwise=0
4	AT SPEED	At commanded speed=1, otherwise=0
5	ACTUAL DIRECTION	CW=1, CCW=0
6	FAULT	Fault=1, No faults=0
7	CLOSED_LOOP	Closed loop=1, otherwise=0
8	PID ENABLE	PID Enabled=1, otherwise=0
9	JERK ENABLED	Jerk Enabled=1, otherise=0
10	JERK CALC NEEDED	Jerk Calculation pending=1
11	INDEX_ACQUIRED	Index Captured=1, otherwise=0
12	SINGLE_PHASE	Singled phase =1, otherised=0
13	OPEN_LOOP	Open Loop operation=1, otherwise=0
14	LAST DIRECTION	CW=1, CCW=0
15	AT POSITION	At position=1, otherwise=0

Example: SA?80 0F =Enabed,Ready,Commutated,Zero Speed, At Position.

SETOUTPUTx:n Set the state of a general purpose output, where x is the output number 1-4 and n is the desired state 0 or 1. Note that the i/o pin must first be configured as an output using the MapOutputx:1 command to map the particular output n as a general purpose output.
Example: Map output 2 as a general purpose output: MAPIO2:1
Set output 2 to 1: SetOutput2:1
Set output 2 to 0: SetOutput2:0

SPEED:nnnnn Sets the commanded run speed in RPM. Range is 1 to TOPSPEED.

SPD:nnnnn Same as SPEED.

SPEED? Responds with the set SPEED value in RPM.

SPD? Responds with the actual speed of the motor in RPM.

STOP	If running, the amplifier decelerates the motor to 0 RPM.
STOPHOLD	If running, the amplifier decelerates the motor to 0 RPM and goes into **Positioning Mode**. See the **GOTO** command.
STOPLEVEL:n	Sets the active level when IO 2 is configured as the Stop input. The valid range for n is 0 or 1.
STOPS:nnnnn	Sets the stop speed in RPM. Range is 1 to the TOPSPEED setting.
SVENABLE:n	Sets the modulation mode, either Space Vector (Field Oriented Control) or Pure Sine wave mode. SVNABLE:1 sets Space Vector modulation, SVENABLE:0 sets Sine wave mode. Note: Only available in Ampmodes 5,6 and 7.
SWAP	Internally swap encoder channels A and B.
SWAP?	Returns “TRUE” if SWAP is enabled and “FALSE” if NOSWAP is enabled.
TOPSPEED:nnnnn	Sets the maximum value for the SPEED and STOPS commands in RPM. The range is stop speed to 50000.
TORQ:nnn	Same as TORQUE command.
TORQUE:**nnn**	Sets the maximum torque output as a percentage of full scale. Range is 0 to 100%.
TORQUE?	Returns the value of the TORQUE setting in %
TYPE:n	Set the commutation type as either “6” for Halls or “7” for encoder. This is only available in amp modes 5, 6 and 7.
VELSCALE:nn	Sets the ratio of RPM (in 1000's) per volt for the analog reverence in analog velocity mode. As an example, if VELSCALE:200 is used, 1 volt in = 200RPM. The range for nn is 1–1000 and the range for the input voltage is/-10VDC. See ANALOGVEL command.
VDGAIN:nnnn	Current loop derivative gain. Range is 0-32767.
VINTLIMIT:nnnnnn	Velocity loop Integration gain limit. 0 – 500,000.
VIGAIN:nnnn	Velocity loop integral gain. Range is 0-32767.
VPGAIN:nnnn	Velocity loop proportional gain. Range is 0-3767.

VOLTS?	List the internal voltages and heat sink temperature in the amplifier as sensed by the DSP.
WAIT:n	Wait n number of mS. Range for n is 1-32000. Useful for creating a delay in program mode.
WRITE	Saves all of the parameter settings to non-volatile memory.
ZERO?	Returns “YES“ if the motor is at zero speed and “NO“ other wise
ZSPDLVL:n	Sets the Zero Speed output polarity when the spindle is at zero speed. Range is 0 or 1.

14 Appendix A – Sending and Receiving Setup Files

14.1 Capturing Settings

The current settings can be captured to a file then loaded into another unit or saved and downloaded for future reference.

1. Configure the amplifier with the desired settings to capture.
2. In the HyperTerminal screen, click on “Transfer”.
3. Select “Capture Text” in the drop down window.
4. A dialog window will open prompting for the name of the file to write the captured data to. Select a file name and use the extension “.txt”.
5. Click “Start”. The dialog window will disappear and the HyperTerminal window will be open. Anything you type will now be captured to the file you specified in step 4.
6. Type “DUMPALL” and press <Enter>. The amplifier will dump all of the settings to the HyperTerminal screen and to the captured file.
7. Click “Transfer” again in the HyperTerminal window.
8. Select “Capture Text” and Select “Stop” in the drop down side bar. The data is now in the file you specified and can be edited as described below.

14.2 Manually Creating a Settings File

If the whole command list does not need to be updated, a file can be created with just the necessary commands to configure the amplifier for the particular application.

1. Open a file using any text editor. Windows WordPad is recommended.
2. Enter each command to send to the amplifier.
3. Press <Enter> at the end of each line to be sure a carriage return follows the command.
4. Save the file.
5. Go to the section on Sending Files to the amplifier below.

14.3 Edit the Captured Settings

1. Navigate to the file specified in step 4 above.
2. Open the file using a text editor. WordPad is recommended.
3. The first few lines of the file should look similar to the following:

```
DUMPALL
>Speed:1100
>
>CCW
>
```

4. Remove the first line containing “DUMPALL”.
5. Review the values for all of the parameters and make any necessary changes. The blank lines with prompts can be removed, but it’s not necessary.
6. The file is now ready to be used to send data to the amplifier. Exit and save the file. NOTE: If the amplifier software version used to capture the settings is less than 2.01.01, please perform the following additional steps to remove the extra characters from the DUMPALL captured commands:

14.4 Sending Files To The Amplifier

1. HyperTerminal must be configured for a 100mS line delay. In the HyperTerminal window, click “File” then select “Properties”. A window will come up with “Connect to” and “Settings” tabs. Click the “Settings” tab. Click the “ASCII Setup” box near the right bottom of the window. In the “Line Delay” box, enter the number 100. Click “Ok” to close that window. Click “Ok” to close the “Settings” window. The HyperTerminal window should now be the only one open.

2. Click “Transfer” in the HyperTerminal main window.

3. Click “Send Text File”. A file dialog window will open. Navigate to and click on the file created when the settings were captured and edited. Click “Ok”

4. The file will be sent to the amplifier. You should see the commands echoed on the screen as they are sent.

5. Write the settings to the amplifier using the “WRITE” command. Alternatively the “WRITE” command can be added to the end of the file to do this automatically when the file is sent.

15 Appendix B – Firmware Updates

It may become necessary to update the firmware in the amplifier if a new release of code becomes available, or if additional features are added. Updates are easily done in the field using a personal computer with a USB or RS-232 serial interface port and a small application program that sends the updated code to the amplifier from the host PC. The amplifier contains a built-in boot loader that updates the firmware via the RS-232 or USB interface. This boot loader becomes active when S2, the programming switch is set to the down position and the amplifier is powered up or reset. In this mode the normal serial interface is disabled and a special programming interface is activated. Please contact the factory for more detailed programming instructions.

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